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The Spitzer Spirals, Bridges, and Tails Interacting Galaxy Survey

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Abstract. We present Spitzer mid-infrared images from a survey of three dozen pre-merger strongly interacting galaxy pairs selected from the Arp Atlas. The global mid-infrared colors of these galaxies and their tidal tails and bridges are similar to those of normal spiral galaxies, thus this optically selected sample of interacting galaxies does not have strongly enhanced normalized star formation rates in their disks or tidal features. Despite distortion and disturbance these systems continue to form stars at a normal rate on average. The morphology of these galaxies is generally smoother in the shorter wavelength IRAC bands than at 8 μm, where dozens of clumps of star formation are detected.

1. Introduction

Since the issue was raised by Larson & Tinsley (1978) and Struck-Marcell & Tinsley (1978), there has been a great deal of interest in how star formation in galaxies is affected by collisions with other galaxies. Infrared Astronomical Satellite (IRAS) observations led to the discovery of galaxies with very high far-infrared luminosities (Soifer et al. 1987; Smith et al. 1987) that are the result of mergers between equal-mass gas-rich progenitors (Sanders et al. 1988). Later studies showed that spectacular enhancement of star formation is the cause of much of the infrared emission in major mergers (see review by Struck 1999).

The question of how star formation is affected in pre-merger interacting galaxies is more difficult to answer. To date, most studies comparing interacting galaxies to normal galaxies have been based on optical data, which suffer extinction, or IRAS far-infrared data, which provides only a global measurement, and is complicated by dust heating by older stars. An alternative tracer of star formation is the mid-infrared (Roussel et al. 2001; Förster Schreiber et al. 2004). With the advent of the Spitzer infrared telescope (Werner et al. 2004), sensitive higher angular resolution mid-infrared imaging of galaxies is now possible, making feasible the detailed study of star formation complexes in interacting systems.

To this end, we have used the Spitzer telescope to observe a well-defined sample of nearby interacting galaxy pairs in the mid- and far-infrared. The high sensitivity and good spatial resolution of Spitzer make it optimally suited for studying induced star formation in spiral arms and tidal bridges and tails, and detecting knots of star formation.

2. The Samples

Our interacting galaxy sample was selected from the Arp Atlas of Peculiar Galaxies (Arp 1966), based on the following criteria: 1) They are relatively isolated binary systems; we eliminated merger remnants and close triples and multiple systems in which the galaxies have similar optical brightnesses (systems with additional smaller angular size companions were not excluded). 2) They are tidally disturbed. 3) They have radial velocities less than <11,000 km/s (150 Mpc, for $H_o = 75$ km s^{-1} Mpc^{-1}). 4) Their total angular size is $> 3'$, to allow for good spatial resolution with Spitzer. 5) The angular sizes of the individual galaxies are $\geq 30''$. A total of 35 Arp systems fit these criteria. One of these systems, Arp 297, consists of two pairs at different redshifts, which are included separately in our sample. We also include the interacting pair NGC 4567, which fits the above criteria but is not in the Arp Atlas. This brings the sample to 37.

Of these 37 systems, 28 were included in our 'Spirals, Bridges, and Tails' (SB&T) Guest Observer Cycle 1 Spitzer program. The remaining 9 galaxies were reserved as part of various Guaranteed Time or Guest Observer programs. For completeness, we also include these additional galaxies. A few of the SB&T galaxies were reserved at some wavelengths and not at others.

As a 'control' sample of nearby 'normal' galaxies, we started with the 75 galaxies in the Spitzer Legacy 'SINGS' project Nearby Galaxies Survey (Kennicutt et al. 2003; Dale et al. 2005). The SINGS sample was selected to cover a wide range in parameter space, with a range in Hubble type and luminosity. Most have angular sizes between $5'$ and $15'$. We excluded from the 'normal' sample SINGS galaxies that are interacting, in close pairs, or in compact groups.

3. Observations

The galaxies in our SB&T sample were observed between November 2004 and November 2005 in the 3.6, 4.5, 5.8, and 8.0 μm broadband filters of the Spitzer Infrared Array Camera (IRAC; Fazio et al. 2004) and the 24 μm band of the Spitzer Multiband Imaging Photometer (MIPS; Rieke et al. 2004). A total of $4 - 23$ dithered exposures of 12 seconds each were made per IRAC filter per galaxy, depending upon the field of view of the system. For the MIPS observations, we used fixed single observations with two cycles of 10 sec integration per frame.

Figure 1. The 3.6 μm (left) and 8.0 μm (right) images of selected Arp galaxies in our sample. North is up and east to the left. The scale bar is $60''$.

4. Results and Conclusions

In general, the galaxies appear smoother in the shorter wavelength IRAC bands, which are dominated by the older stellar population, than at 8 and 24 μm (see Figures 1 − 2). In the longer wavelength bands, multiple clumps of star formation are visible, in both the disks and tidal features. For example, star forming clumps are visible in our Spitzer images of the tidal arm/ring of the peculiar galaxy Arp 107 (Figure 1), and a gradient in the age of the stellar population is detected along this feature (see Smith et al. 2005). In Arp 82, young star forming clumps are also present in the disk and tidal features (see Hancock et al., this proceedings).

On average, the Spitzer colors of the disks and tidal features of the Arp galaxies are similar to those of normal spirals. Therefore this optically-selected sample of pre-merger interacting galaxies does not have strongly enhanced star formation compared to non-interacting galaxies.

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Figure 2. The 3.6 μm (left) and 8.0 μm (right) images of selected Arp galaxies in our sample. North is up and east to the left. The scale bar is 60″.

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